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STEREOSCOPIC EFFECTS OBTAINED BY THE HIGH-POWER BINOCULAR ARRANGEMENT OF POWELL & LEALAND.

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Many observers would believe they obtain stereoscopic effects by means of the Powell & Lealand binocular arrangement for high powers, were it not for the fact that the construction of the arrangement theoretically forbids. The two images, falling one upon each retina, are precisely alike; the perspective of one differs in no way from the perspective of the other. It is said, therefore, that all such effects are imaginary, and said to the disparagement of all observers who have felt the effects to be genuine.

Notwithstanding, and to put the disparagement on the other shoulders, where mere theory blindly has had the advantage over actual observation, I wish to show one can and does obtain under quite ordinary conditions, stereoscopic effects, both orthoscopic and pseudoscopic, by means of the binocular arrangement in question, and, moreover, that theoretically one ought so to do.

Although the whole matter appears simple enough now, one was at first obliged to stand alone in defense of both experiment and theory. Mr. Thomas Powell himself seemed to regard experiment hardly worth repetition, and wrote he did not believe it possible to obtain stereoscopic effects by means of the high-power arrangement. But when unprejudiced eyes began to look, the dem-

onstration was regarded as satisfactory. Mr. Edward Bausch was the first to so regard it. Then followed the well-known Messrs. Ingpen and Crisp, of London, and Prof. Abbe, of Jena. Accepted by such an array, the truth of this really very simple matter can be regarded as established.

If a piece of paper be held just above the eye-piece of a monocular compound microscope, in condition for use, on the paper appears a circular spot of light, an image of the posterior clear aperture of the objective, which is known as the Ramsden circle. If the piece of paper be held above the right tube of a Wenham binocular arrangement, on the paper appears only the right half of the Ramsden circle. If the piece of paper be held above the left tube, only the left half of the Ramsden circle appears. When, by means of double tubes or double eye-pieces, the right half of the Ramsden circle is caused to correspond with the right eye, and the left half-circle with the left eye, the eye-pieces being negative, the right eye sees the image of the object in right eye perspective, and the left eye the image in left eye perspective, and, consequently, the necessary conditions are present for the stereoscopic, orthoscopic vision by means of the compound microscope. If, on the other hand, the right half-circle be caused to correspond with the left eye, and the left half-circle with the right eye, instead of orthoscopic effects, pseudoscopic effects are obtained; that is to say, all convexities appear concave, and *vice versa*. (The full exposition of the relation of the halves of the Ramsden circle to stereoscopic vision with the compound microscope, appears in the *Journal of the Royal Microscopical Society* for April, 1881, in a paper "On the Conditions of Orthoscopic and Pseudoscopic Effects in the Binocular Microscope, by Professor E. Abbe, Hon. F. R. M. S.")

If a piece of paper be held above first one and then the other tube of a binocular furnished with the Powell & Lealand high-power arrangement, in each instance a whole Ramsden circle appears, and, therefore, the conditions for stereoscopic vision are not present. If, however, by means of diaphragm caps, fitting over the eye-pieces, the right half of the left circle and the left half of the right circle, or, in other words, the inner halves, be cut off, the outer half-circles

left give orthoscopic effects; while if the opposite or inner halves of the circle be left clear, by turning each cap half way round, pseudoscopic effects are obtained. Prof. Abbe has farther shown if one whole Ramsden circle be caused to correspond with one eye, and half a circle with the other, stereoscopic effects are also obtained; but that the effects give only half the sense of relief or solidity as do the effects obtained when the opposite halves of the Ramsden circle correspond respectively with each eye. He has shown, too, how other non-stereoscopic binocular arrangements, as well as the high-power arrangement of Powell and Lealand, can by means of similar eye-piece caps, be made to give orthoscopic and pseudoscopic effects. He has not, however, pointed out the fact that the same results can be obtained by simply racking the binocular tubes first a little too far down and then a little too far up, thus causing the Ramsden circles to approach or recede from one another, and that the eye-piece caps are therefore simply aids to the eyes and not necessities.

If the centers of the Ramsden circles, one above each of the two eye-pieces, be at first separated by a distance exactly corresponding with the distance between the pupils of the two eyes, a sugar semi-pill, crossed with pencil marks for greater effect, resting flat surface down on a black card under the objective, appears comparatively flat. Now, if the tubes be racked down a little, the distance between the pupils corresponds first with the distance between the center of one Ramsden circle and the center of the outer half of the other; and, later, with the distance between the centers of the outer halves of the two Ramsden circles; and, consequently, as the conditions for orthoscopic effects are present, the semi-pill appears convex. Again, if the tubes be racked up a little beyond their original position, the distance between the pupils corresponds first with the distance between the center of one Ramsden circle and the center of the inner half of the other; and, later, with the distance between the centers of the inner halves of the two Ramsden circles; and, consequently, as the conditions for pseudoscopic effects are present, the semi-pill appears concave.

Inasmuch as it is quite common for microscopists to use binoculars with tubes racked more or less too far down, and occasionally

racked too far up, it follows that stereoscopic effects, both orthoscopic and pseudoscopic, can be and are obtained under quite ordinary conditions by means of the Powell & Lealand binocular arrangement for high powers.